Procedures for the Initial Subdivision of Sections
Jan. 16, 2004

Overview:

This document outlines the procedures for the automatic **initial** subdivision of sections in a PLSS township, which is referred to in the Detailed Use Case MM 1.11 – Section Subdivision. Before initial subdivision of sections there are only point and line features defined by adjusted measurement data. After initial subdivision there will also be point and line features constructed by "COGO instructions" to the $1/16^{th}$ corner (40 acre parcel) level. "COGO instructions" consist of coordinate geometry methods and the parameters to construct a new point. The COGO instructions will persist in the database in order to re-create point coordinates whenever the underlying measurement data is readjusted. There are six other aspects of section subdivision that are treated in other documents:

- Editing the COGO instructions. This is needed when the instructions are incorrect or if there is new data.
- Utilizing symbology during data review/edit to ascertain the computation method of each point. Refer to subdivision-symbols.doc
- Applying COGO instructions after readjustment of the measurement network. There is a need to automatically resubdivide all sections whose underlying data has been changed, either by least square adjustment or modification of COGO instructions. This is a straightforward and transparent process of applying the COGO instructions that persist in the geodatabase.
- Migrating the GMM subdivision data files into the NILS geodatabase. Refer to SM/MM Import Use Case.
- Performing minor subdivisions based on land descriptions in LR2000. Refer to subdivision-minor.doc
- Determining the legal position of a point for laying out the subdivision of sections in the field or restoring lost corners. See Use Cases MM1.01 through MM1.13.

Pre-existing GCDB data collection rules that algorithms can leverage:

Data Collection Prerequisite #1: [ambiguous proportions solved during initial collection] In GCDB collection, if any subdivision points on an exterior section line (like 1/4 corner or 1/16th corner) are **not** at midpoint, then the points are included into the measurement data. The reason for this is that there is not enough data in digital format to solve the problem of proportioning. The problem is solved while the plat is being interpreted by the user during initial collection, with the resulting proportioning solution being embedded into the measurement data. There are, however, points in the interior of the section that will need to be created through proportions.

Data Collection Prerequisite #2: Use the GCDB Point Identification convention when assigning unique identifiers to each point. The function of the corner is then easily determined later by algorithm and by user.

Section Subdivision Imperatives: Following are some rules that simplify all steps of the subdivision process:

- Never construct a point or line that already exists in the survey measurement network.
- Use geodetic formulas on rhumb lines, planar formulas on straight lines. Generally section exteriors are rhumb lines (geodetic flag set to true) and interior section subdivision lines are straight, but different managers should be able to override this rule and set interior section subdivision lines to rhumb lines.
- In calculating proportions, always use the measurement data that 1) has a SID value that ends in "-TIE" and 2) is not listed in the GMM NOT file.
- If an interior centerline has been surveyed, but no subdivision corners have been placed on that line, then that line will still be used as the centerline, and will be treated as a straight line.
- After each calculation is defined, store the parameters that were used in the calculation.
- Utilize the GCDB point identification system to recognize the function of the corners. Points with prefix values 702 and 710 are points for special surveys occurring on the East boundary of the township. Points with suffix values of 702 and 710 are points for special surveys occurring on the North boundary of the township. Point IDs 711000 and higher are special surveys.

Definitions:

Non-cardinal. In the context of this document, a "non-cardinal" line is a line with a direction not within 5 degrees of cardinal and the point ID value for at least one endpoint is over 710999.

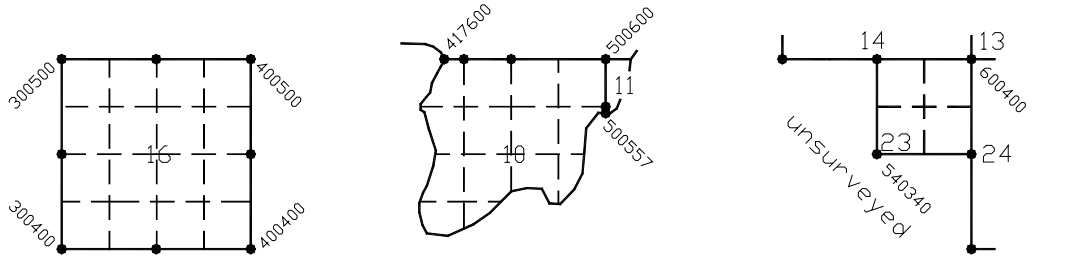
Controlling corner. In the context of this document, a "controlling corner" is a corner up greater of higher status that controls the proportionate/midpoint calculation of the corner being computed. Section corners are controlling corners for exterior 1/4 corners so section corners are at the top of the highest level of status, followed by exterior 1/4 corners, center 1/4 corners, section line and center-of-section line 1/16ths, then center of section quarter 1/16ths.

Recommended order and methodology - Section Exteriors:

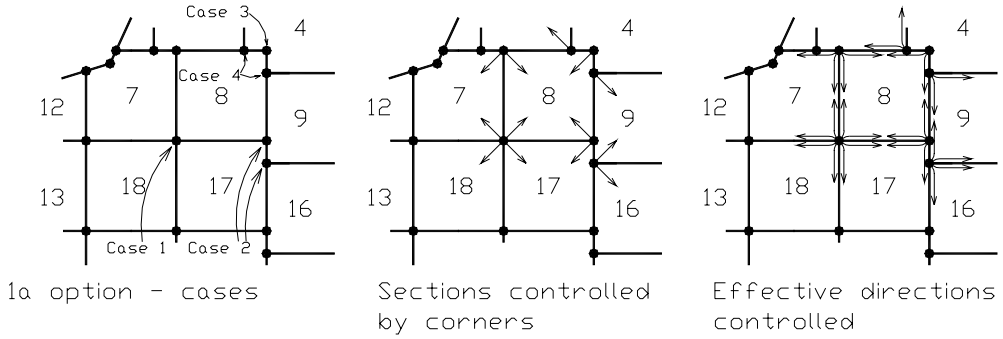
In a nutshell: There are 15 stages for section subdivision, coincident with the 15 numbered sections of this document. 1) find features on section exterior, 2) calculate midpoint 1/4 and 1/16th corners on section exterior, 3) identify endpoints of sectional centerlines, 4) find sections thin or short enough to apply truncated rules, 5) find sections wide or tall enough to apply elongated rules, 6) validate progress, 7) inventory unsolvable sections, 8) inventory interior subdivisional points/lines within measurement data, 9) create section centerlines, 10) create center 1/4 corners, 11) create centerline 1/16ths, 12) create centerlines of section quarters, 13) create center 1/16ths, 14) complete final line work, and 15) label polygons with the nominal locations.

1) **Inventory the section exterior features**: Inventory and catalog all point and line features on the section exterior.

1a) Check for missing section corners, using GCDB IDs as a major identifier, and by using geometry. If missing, then the section is either truncated by a non-cardinal survey or partially surveyed. Notice that in Figure 1a, section 10 has only one true section corner, which occurs where two section boundaries intersect. An intersection of the section line and of the non-cardinal section exteriors is a terminus of the section line and is used for alignment of the section lines, but not for proportioning of corners in the section interior. Section 23 of Figure 1a also has only one section corner. A future survey would determine whether the SW corners of secs 14 and 24 will be used as section corners for section 23.



1a Option) An optional strategy: Make an initial determination of the sections in which a section corner maintains control for the purpose of constructing proportioned corners on the exterior. This can be determined by examining how the section lines intersect with neighboring sections. There are four cases available:



Case 1) If there are four rectangular lines connected to the corner, then the corner controls in four directions: to sections toward the NE, NW, SW and SE. Refer to sections 7, 8, 17 and 18.

Case 2) If there are only three rectangular lines connected to the corner, then the corner controls in only two directions. Example: if the rectangular lines that connect are only to the N, S and E then the directions of control are to polygons toward the NE and SE. Refer to the corner common to sections 9 and 16. Example: if the rectangular lines that connect are only to the N, S and W then the directions of control are to polygons toward the NW and SW. Refer to the corner common to sections 8 and 17.

Case 3) If there are only two rectangular lines connected to the section corner, at about right angles, then the corner controls in only one direction. Example: if the rectangular lines that connect are only to the S and W, then the direction of control is to the polygon toward the SW. Refer to the northwest corner of section 8.

Case 4) If adjacent section lines do not connect to a common corner, but to the boundary of another section (refer to sec. 4 in Fig. 1a Option), then that section has what is called “double section corners”. These have the point IDs indicating section corners, but are not true section corners. These are equivalent to termination of section lines, as seen in section 7 of Figure 1a Option. These termination lines control the alignment of the section boundary, but are not used in proportion calculations for points in the interior of the section. In the case of double section corners, all proportioned corners along the section line will have been computed and entered into the measurement data, as stated in Data Collection Prerequisite #1, above.

1c) Identify the perimeter of each section by inventorying the points and record measurements on the section exterior.

1c1) Identify up to 4 sides of the section: N, E, W and S.

1c2) Identify where section exteriors transition into non-cardinal surveys such as points 417600 and 500557 seen in Section 10 in Figure 1a.

1c3) Store the overall distance of each section side, for further use. **Important: Use the dimensions from the unadjusted survey data to determine rectangularity, proportions and tolerances. The coordinate geometry instructions have parameters derived from unadjusted survey line data, but are applied to adjusted coordinates. The only exception, found below in stage 11a4, is for the dimensions of lines that were constructed, not measured. The bearing and distance of a constructed line is derived from its adjusted coordinate positions.**

1c4) If the dimensions of the section sides are within 2½% of a mile in distance, and all directions along the side are within 5 degrees of cardinal, then assume that the section side meets specifications for rectangularity.

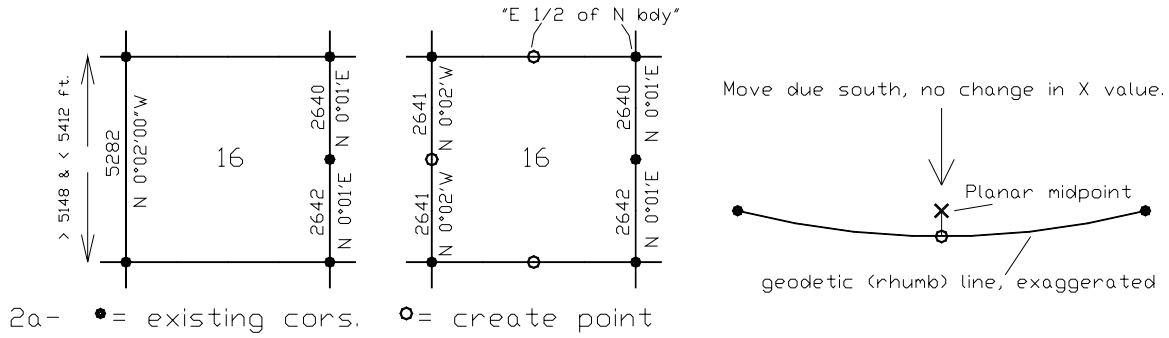
Note: the inventory will become more densely defined later, for instance the "N½ of the S½ of the West boundary" will have a record distance.

2) **Calculate midpoint corners along rectangular section lines**: If a side or segment is within certain geometric tolerances, discussed later, calculate the midpoint corner coordinates and point identifier. If the corner exists identify the record distances from the corner to the controlling corners to either side. After computing or recognizing an existing midpoint, then break the section side into two identifiable segments, i.e., "N½ of the W side" and "S½ of the W side". Assign half of the record distance to the remaining segments.

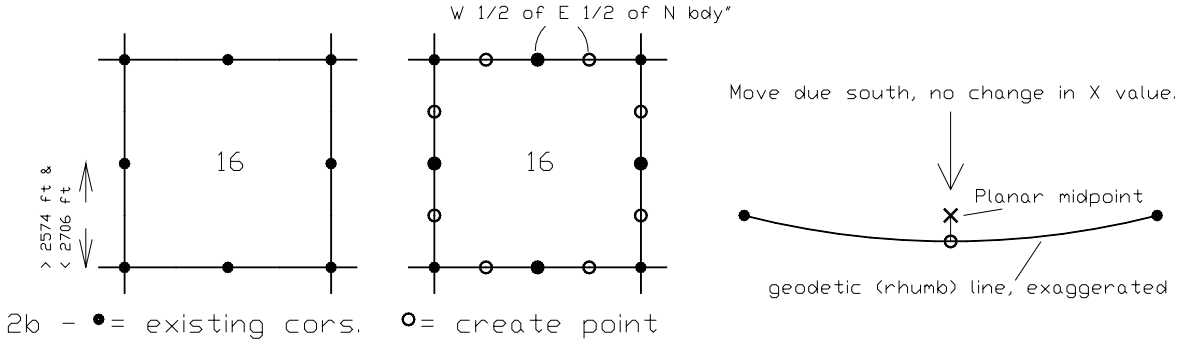
> There are not enough kinds of data collected to support the classic inexact decision-making about which course of action to take in creating legal section subdivisions. This document contains distance and bearing tolerances that should result in the most correct answer for our purpose. Our purpose is not to create a legal determination of a section subdivision, but to reduce the amount of time editing data. The user ultimately will edit the data to ensure that it reflects the intent of the survey plat.

It is possible that these tolerance values may not be satisfactory to all. Eventually these tolerance values may be defaults, which may be edited by the user or only by a supervisor.

2a) If a section's record boundary is between 78 and 82 chains (5148 and 5412 ft) and the 1/4 corner is not included in the survey data and there are no "non-cardinal" lines along that section boundary, then it can be assumed that the 1/4 corner is at midpoint. Calculate cardinal midpoint by distance and create the 1/4 corner point along the geodetic line at that cardinal midpoint. Stated another way, find the average coordinates between the two controlling corners and intersect the geodetic line with a line drawn cardinally from the averaged coordinates. This method is always used with proportionate calculations along section exteriors, including midpoints.

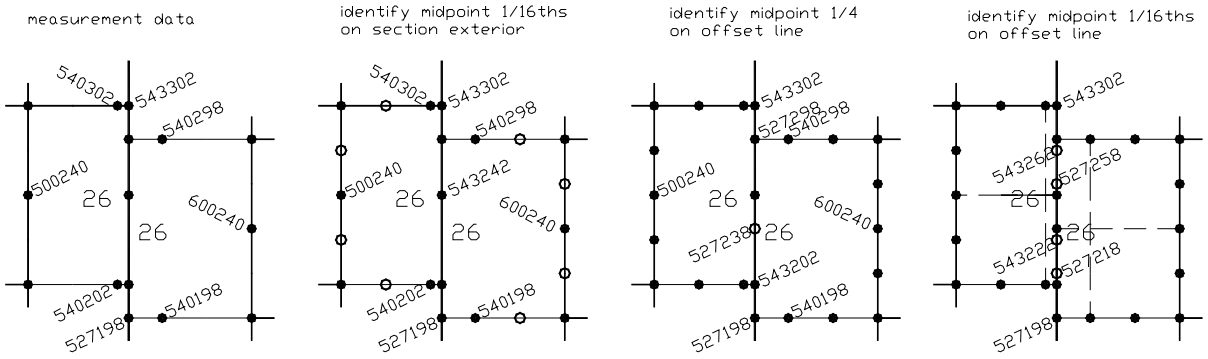


2b) If a section's record boundary between a section corner and an adjacent 1/4 corner is between 39 and 41 chains (2574 and 2706 ft) and the 1/16th corner is not included in the survey data and there are no "non-cardinal" lines along that boundary portion, then it can be assumed that the 1/16 corner between them is at midpoint. Calculate planar midpoint by distance and place the 1/16th corner along the geodetic line at that cardinal midpoint. Stated another way, find the planar midpoint between the two controlling corners, and then intersect the geodetic line with a line drawn cardinally from the planer midpoint.



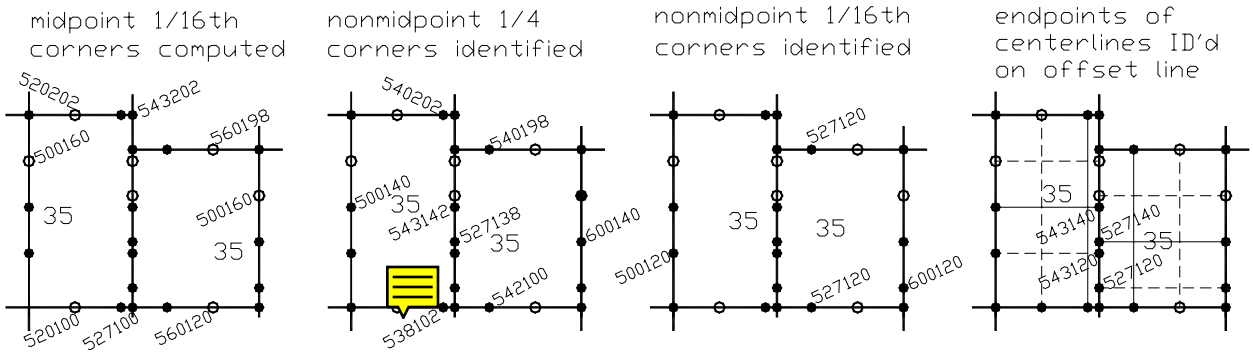
2b - ● = existing cors. ○ = create point

2c) If a line passes through the section to another section boundary, causing jogs along the section line (section lines terminate onto this line) and all segments of the line are within 5 degrees of cardinal, then the section is internally offset by a near-cardinal line. Another check on this is that a section line will terminate on this line at different points, coming from opposite directions. Treat each side as a truncated section. It is possible to create corner points at midpoint along this near cardinal line if the record distance is within the above-stated (Stages 2a and 2b) tolerances. These new points will form the terminus of interior subdivision lines.



2c - offset within section interior.
Example of 6 exterior 1/4 corners and 2 center 1/4 corners.

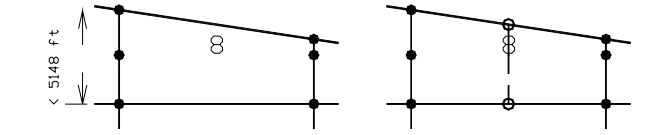
3) **Identify endpoints of section centerlines and endpoints of centerlines of quarter sections. Break the section sides into segments between adjacent sectional corners**. The identifiable points at this stage will be points whose prefix or suffix indicates a quarter corner or 1/16th corner and the suffix or prefix, respectively, indicates a section exterior or a cardinal line that creates an offset within the section.



3 - Inventory 1/4 and 1/16th corners on exterior and offset lines.

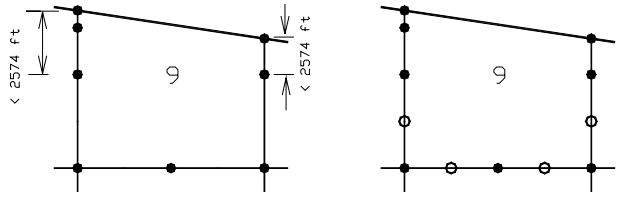
4) **Section foreshortened by senior survey or unsurveyed area**: Determine if the dimensions of the section suggest a foreshortened section. Inventory known exterior corners and exterior corners not to compute.

4a) If a section's record boundary between section corners is less than a tolerance of 78 chains (5148 ft), then check for the existence of the 1/4 cor. If it does not exist, then it shall not be computed.



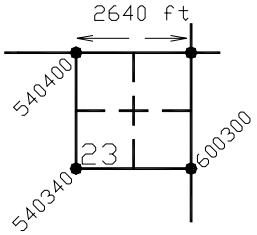
4a - Section boundary less than 5148 ft

4b) If the quarter corner exists, and the distance to either adjacent section corner is less than a tolerance of 39 chains (2574 ft), then check for the existence of the intermediate 1/16th. If it does not exist, then it shall not be computed.



4b - Distance to 1/4 corner < 2574 ft

4c) Some sections are partially surveyed (truncated by unsurveyed areas). These cases are identified by a section exterior following lines normally used for the interior subdivision of sections.

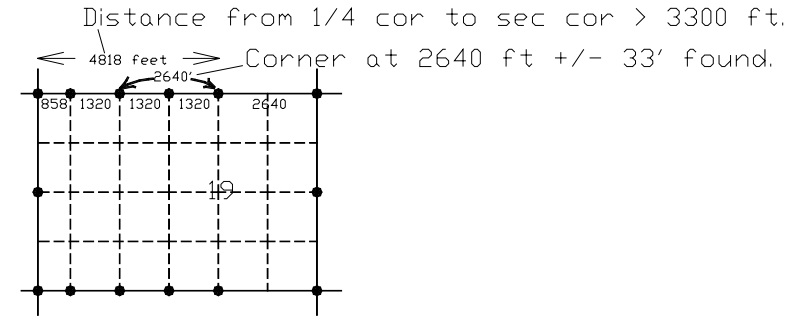


4c - Distance of section < 5148 ft

5) **Elongated Section:** Determine if the dimensions of the section suggest an elongated section.

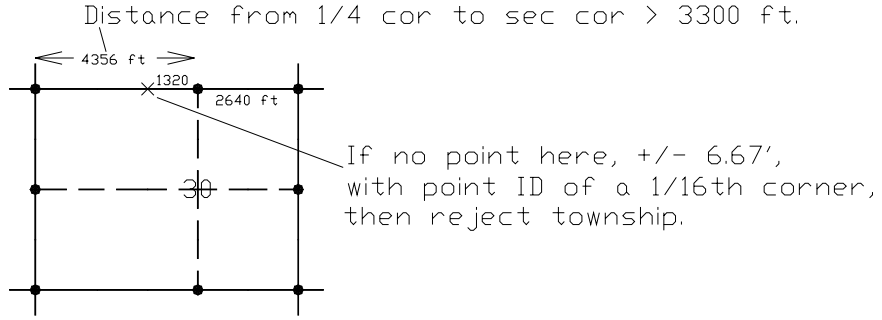
If the distance from a quarter corner and an adjacent section corner is greater than 62 chains, then the section may be elongated.

5a) If there is an adjusted corner 40 chains +/- .5 chains (2640ft +/- 33ft) record distance from the 1/4 corner toward the most distant section corner, then the classic rules of data collection were followed. See Data Collection Prerequisite #1, above.



5a - Elongated to West 2 tiers

5b) If there is NOT an adjusted corner 20 chains +/- .1 chains (1320 +/- 6.67 ft) record distance from the 1/4 corner to the most distant section corner, then the section was collected with an exception to the rule about non-midpoint corners. In this exception to the Data Collection Prerequisite #1, the overall elongated distance from the 1/4 corner to the section corner was collected and the position of the normal 1/16th and elongation 1/16ths is implied. When GMM subdivides these sections the COGO instructions are created from assumption and stored in the .ADD file, which is imported into NILS. If there are any rare cases where the measurement data was collected, but not yet subdivided, then the township should be rejected so the user can enter in the data explicitly.



5b - Elongated to West, without needed pts.

6) At this point the **section exterior boundary is identified** and:

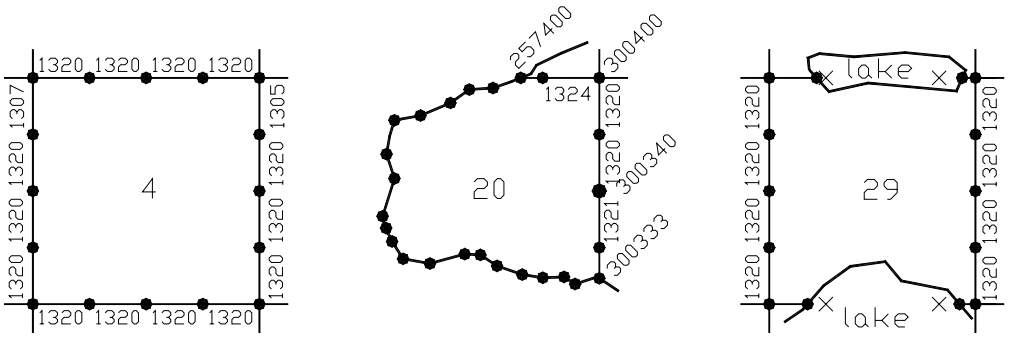
6a) All points where the section exterior changes from rectangular to non-rectangular have been identified

6b) All lines causing an offset within the sections have been identified and the section has been split into two identifiable units.

6c) All possible section corners, 1/4 corners, 1/16th corners and elongated corners have been identified or calculated.

6d) All corners that should not be calculated for each section boundary have been identified.

6e) The record distance between each exterior 1/16th corner point and its adjacent section or 1/4 corner should be accounted for. These values will be used later in calculating the centerline of section 1/16th corners. If the section side terminates onto a non-cardinal line or the 1/16th corner does not exist, then the distance is irrelevant.



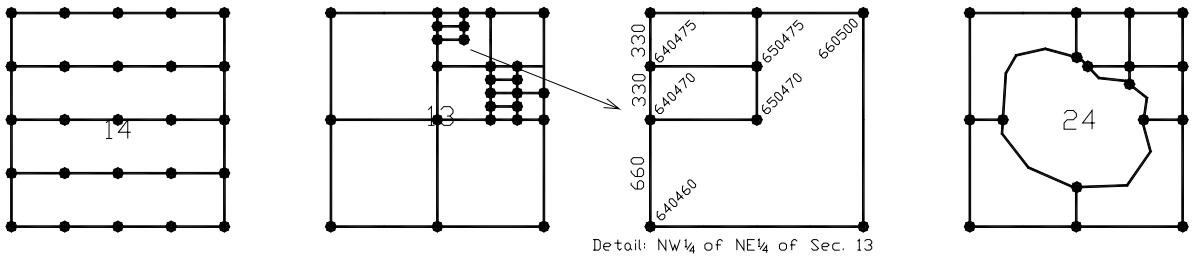
6e - Inventoried record distances

7) **Inventory unsolvable sections.** List problems in a log file**.**

If there are configurations of data that prevent the system from accomplishing the landmarks listed in Stage 6, above, then the sections involved must be solved by user intervention. A log file should be created to record where these problems are. If the problem can be described, then that error message should be in the log file. All "solvable" sections should be automatically subdivided prior to moving to the next township.

<u>Recommended order and methodology - Section Interiors</u>:

8) **Inventory interior subdivision points and lines that exist in the measurement data**, including minor subdivision. Hint: Interior lines that terminate at 1/4, 1/16th, 1/64th and 1/256th corners are good starting points in the search because both the prefix integer and suffix integer of their point IDs are multiples of 5. (See detail of Section 13 in Figure 8, below.) Also note cases where a centerline of section or a centerline of a section quarter terminates in a non-cardinal line. This event suggests that subdivision is not defined beyond the non-cardinal line and all interior subdivisional lines will terminate against this line. (See Section 24 in Figure 8, below.)



8 - Inventory interior subdivision lines.

9) **Create line entities representing the centerlines of the section** using planar geometry.

9a) If opposite 1/4 corners exist, create a straight line between the opposite 1/4 corners. See section 16 in Figure 2a.

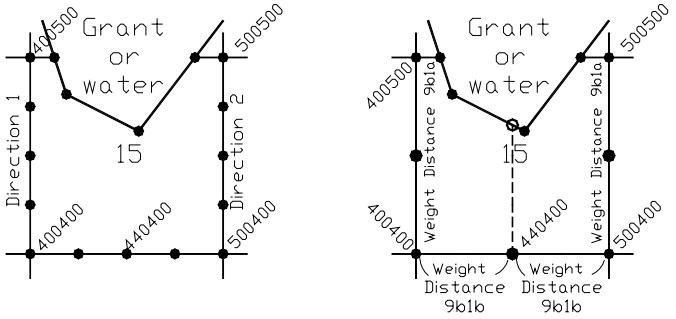
9b) If one opposite 1/4 corner does not exist, create a line and point from the 1/4 corner that does exist to its intersection with the section exterior line(s) (ref. Meanderable Lake in Figure 47[4]), using the bearing obtained as follows:

9b1) If the two boundaries to the side exist, create a centerline using weighted mean bearing calculated using bearings from the whole section boundaries to either side. In Figure 9b1 the centerline northerly from point 440400 is influenced by the bearings of the lines 400400 to 400500 and 500400 to 500500. It is

not an average however. It is a weighted average. There are two ways to apply weights to the calculation:

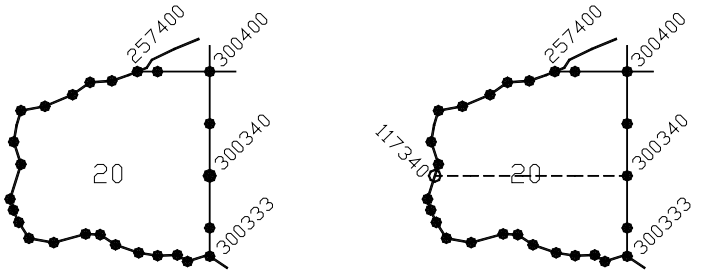
9b1a) The length of each section side influences the solved bearing value. If one side is three times the length as the other side, then the bearing of the long side has a weighting of three times the amount of the short side. In Figure 9b1 the distance of the line from 400400 to 400500 is compared to the distance of the line from 500400 to 500500.

9b1b) The position of the existing 1/4 corner between the section lines to either side influences the solved bearing value. Example: If the distance from a South 1/4 corner to the SW section corner is three times the distance from that same 1/4 corner to the SE section corner, then the bearing of the East boundary of the section will have three times the weighting than the bearing of the West boundary of the section. In Figure 9b2 the distance of the line from 400400 to 440400 is compared to the distance of the line from 440400 to 500400



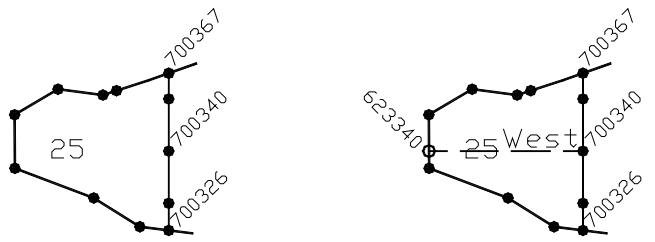
9b1 - Create centerline with weighted mean bearing.

9b2) If only one boundary to the side exists, draw a centerline parallel to the section side. In Figure 9b2 below, the centerline from point 300340 is drawn parallel with the line 300400 to 257400.



9b2 - Create centerline with parallel line

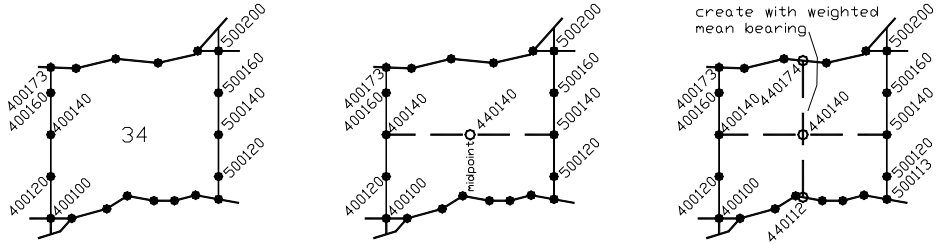
9b3) If there are no lines to either side of the potential centerline, then create the centerline from the existing 1/4 corner on a cardinal bearing to the other side of the section. In Figure 9b3, the centerline is created due west from the 1/4 corner 700340.



9b3 - Create centerline with fixed bearing

9c) If neither of the opposite 1/4 corner exists, then create a center 1/4 corner on the other centerline as follows:

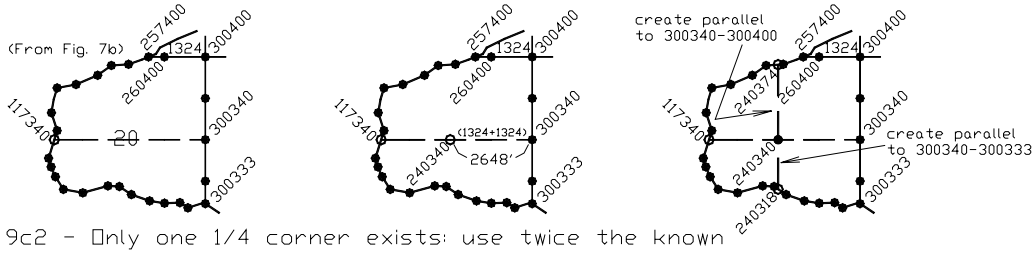
9c1) If both opposite 1/4 corners exist on the other centerline, then a straight line exists between them from Stage 9a. Place the Center 1/4 at midpoint along this line.



9c1 - Opposite 1/4 corners missing, use midpoint on straight line between other 1/4 corners

Create missing centerline using bearings derived with Stage 9b techniques. Create points at intersection of centerline with the section exterior.

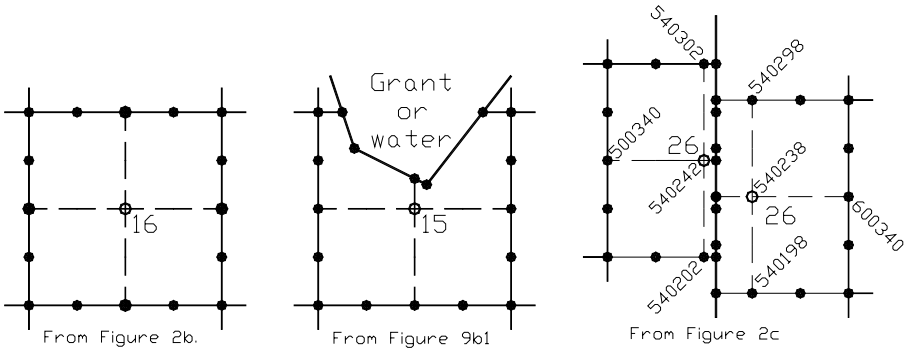
9c2) If only one 1/4 corner exists on the section exterior, then place the 1/4 corner on the centerline at twice the distance calculated for placement of the closest centerline 1/16th (See Stage 11, below). If no record distance exists that is relevant to the computation, create the point at 1/2 mile (2640.00 feet).



9c2 - Only one 1/4 corner exists: use twice the known controlling distance, or 1/2 mile if no controlling distance.

Create missing centerline by applying 9b techniques to derive bearings. Create points at intersection of centerline with the section exterior.

10) **Create Center 1/4 at the intersection of these two centerlines**, if the centerlines intersect, and if the Center 1/4 does not exist.

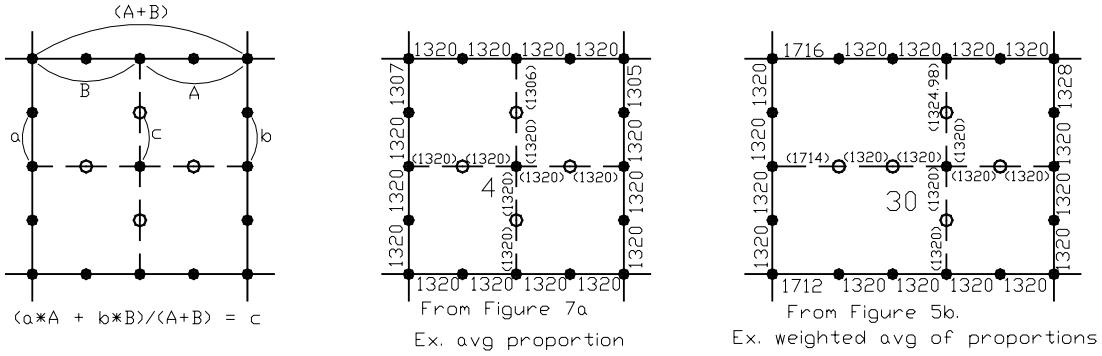


10 - Create Center 1/4 at intersections of centerlines

11) Create centerline 1/16th corners using relevant record distances from Stage 7. These relevant record distances will control the final value for placement of each centerline 1/16th, which is the positional relationship along the line it is placed. This is done by computing provisional distances along the centerline based on the record distances existing (or not existing) to either side of the centerline. For example, the distance from the center 1/4 corner to the 1/16th corner to its north is the distance of the "south half of the north half" of the centerline, which is influenced by the "south half of the north half" of the West exterior of the section and 2) the "south half of the north half" of the East exterior of the section. These relevant record distances will be referred to now as the "controlling distances" for the provisional distance along the centerline which we wish to determine.

11a) If both controlling distances exist then the provisional distance (to the 1/16th) is a weighted average of the two controlling distances. The weighting is determined from the proportionate distance of the section centerline between the exteriors. the exterior lines at either side, then the combination of relative positions is a mere average. If the centerline is not at midpoint between the exterior lines, then a proportion is determined based on the centerline's position between the section exteriors to either side. If the calculation is done right, it will nearly approximate what would happen if an intersection is made of the centerline with the line formed between the equivalent exterior 1/16ths at either side.

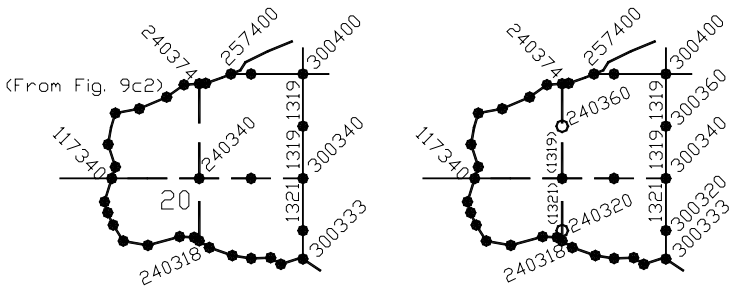
11a1) If both exterior 1/16ths in the equation have proportionate values defining their relative positions, then those proportionate values are combined into a weighted value to arrive at a proportion. This proportion is applied to the inversed distance between the Center 1/4 and the exterior 1/4 to establish each centerline 1/16th along the centerline.



11a1 - Average controlling distances, using weighting from relative position of centerline between section sides.

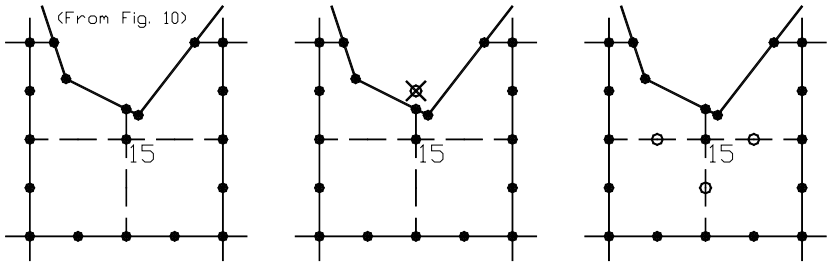
11a2) If proportions cannot be used due to a section line or interior centerline terminating on a non-cardinal line, then use a fixed distance, based on the weighted combining of the record distances of the equivalent segments along the section exterior. In Figure 11a2 below, the distance of the line from

300340 to 300320 (1321 ft) is used to create point 240320 from point 240340. The distance of the line from 300340 to 300360 (1319 ft) is used to create point 240360 measured from point 240340.



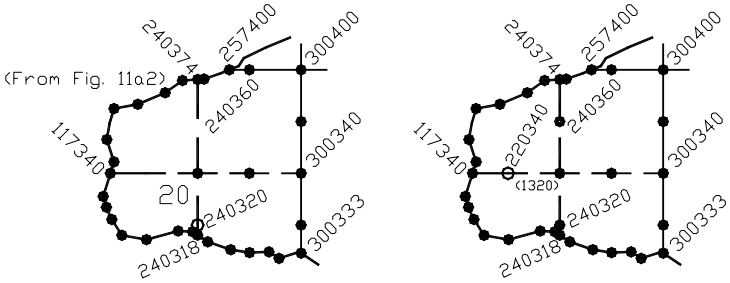
11a2 - Use single record distance if opposite distance is not relevant.

11a3 If the coordinate solution indicates a new point outside the section, then no point is created.



11a3 - Do not compute if solution is not in the section.

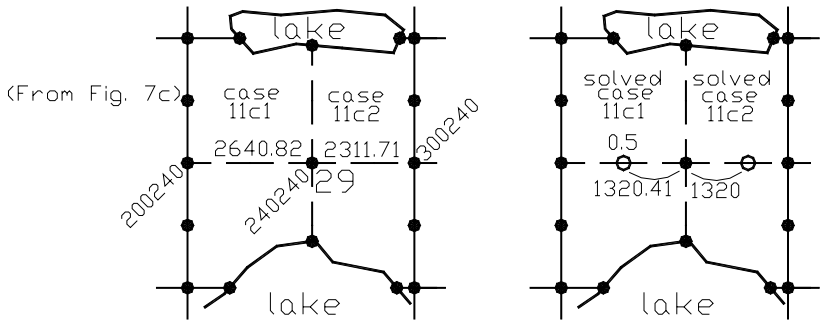
11a4) If neither controlling distance exists and the centerline terminates onto a non-cardinal line, use the distance of 1/ 4 mile (1320.00 feet) as the provisional distance.



11a4 - Use 1/4 mile if no record distance can be applied.

11b) If both provisional distances to/from a centerline 1/16 have been determined, then those distances form a proportion that describes the relative position of the centerline1/16th between the adjusted coordinates of the center 1/4 and the exterior 1/ 4 corner.

11c) If there are no controlling relationships to either side, then the distance between the **adjusted coordinate values** of the center 1/4 corner to the exterior 1/4 corner becomes the controlling factor:



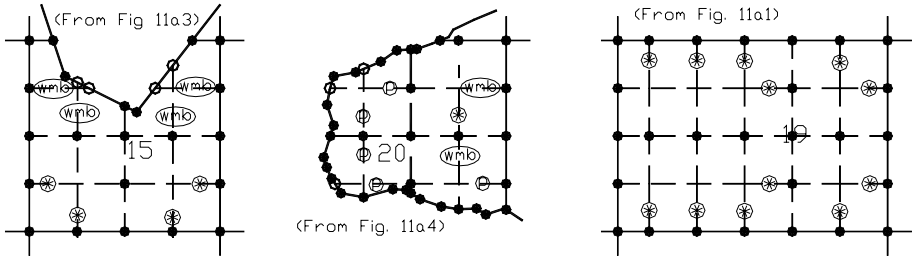
11c - Use midpoint or fixed distance if no record measurement can be used.

11c1) If the distance from the center 1/4 corner to the exterior 1/4 corner is between 39 and 41 chains (2574 and 2706 feet), then create a centerline 1/16th corner at midpoint.

11c2) If the distance from the center 1/4 corner to the exterior 1/4 corner is not between 39 and 41 chains (2574 and 2706 feet), then create a centerline 1/16th corner ¼ mile (1320 feet) from the center 1/4 corner.

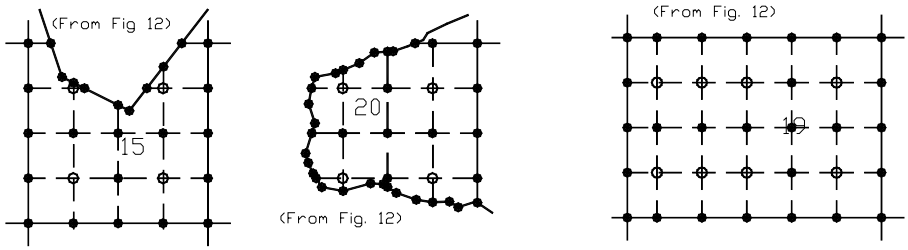
11d) If one of those two controlling 1/4 corners is missing, then use a fixed distance of ¼ mile (1320 ft) from the controlling 1/4 corner. See the centerline W 1/16th corner in Figure 11a4, above

12) **Create the centerlines of section quarters.** Determining these centerlines is the same decision path as in determining the centerlines of sections. Refer to discussion in stages 9a through 9d, above. If not connecting between two corners, then create a point at intersection with the new line and any non-rectangular portion of the section exterior.



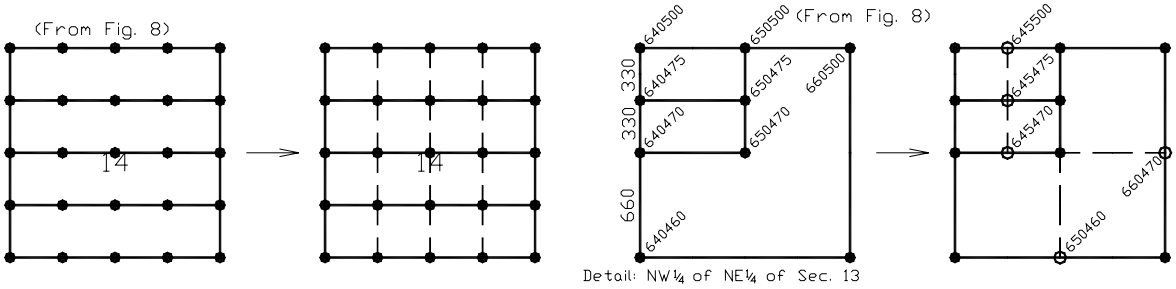
12 - Create centerlines of section quarters and elongation lines.
⊛ = connect between centerline 1/16th and exterior 1/16th corners
Ⓟ = parallel (wmb) = weighted mean bearing

13) **Create the Center 1/16ths.** Determine the Center 1/16th is the same decision path as in determining the Center 1/4 position. Refer to stage 10, above.



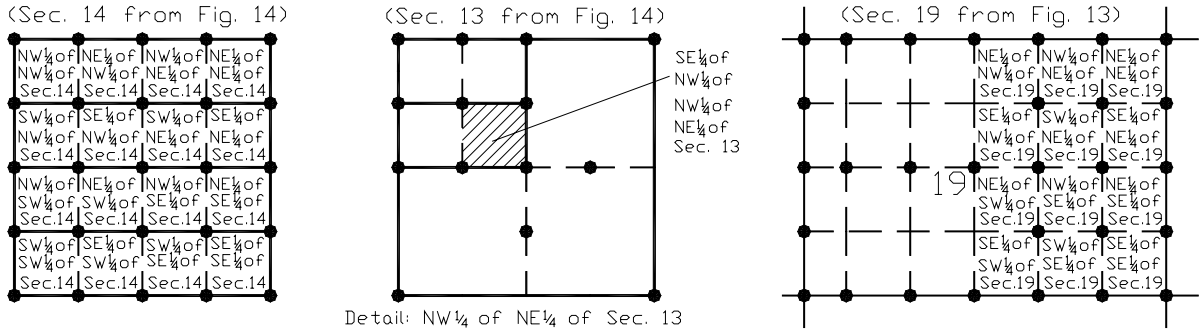
13 - Create center 1/16th corners and elongated 1/16ths

14) **Finish final line work by creating line and point features.** At this point all points have been created. In some situations like the 3-mile method in Section 14 in Figure 14 below, not all lines have been identified because it was not necessary to create the line in order to create the point. In some situations of field-surveyed minor subdivision, not all the lines and points were created to "quarter" the 40 or 10 acre aliquot piece, but they are understood to exist. In order to properly attribute these remaining areas it is necessary to create line work in these "understood to exist" situations. An example is the survey that defines the NW ¼ or the NW ¼ of the NE ¼ of Section 13 in Figure 14, below. The polygon consisting of the NE, SW and SE quarters of the NW ¼ of the NE ¼ needs to be broken down into its component parts and the two polygons representing the N ½ and the S ½ of the NW ¼ of the NE ¼ needs to be broken down into its component parts.



14 - Finish creating line and point features.

15) **Assign nominal locations to all polygons within the section.** Polygons in the elongated portion of a section do not have standardized nominal location descriptors.



15 - Assign nominal locations to subdivision polygons

For further reference, consult the Manual of Surveying Instructions, 1973. BLM Technical Bulletin 6 and Appendix A.doc from the WinGMM Technical Reference Manual for guidance on GCDB Point ID convention